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Ingressing Patterns of Life

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Most of the great questions of philosophy are on display in a single fertilized egg. One cell divides, then divides again, and soon a complex organism is taking shape. Order emerges at every scale, until what began as quiescent protoplasm becomes a living being capable of hopes and dreams—and, in the case of humans, the self-reflection needed to insist that it is more than a machine.

How does such a transformation occur? How does matter obeying chemistry and physics cross into the domains of behaviour, thought, and even psychoanalysis? This passage happens on two scales: in our own development as embryos, and in our evolution from single-celled ancestors. Neither journey reveals a sharp threshold where the mind suddenly switches on. Capacities emerge gradually, scaling up from humbler competencies. To understand our origins, we must formulate models of transformation rather than search for abrupt beginnings.

Another lesson of embryogenesis is that intelligence is always collective. We are composed of parts—cells, tissues, organs—that together produce goals and behaviours no part could generate alone. The same logic unites ant colonies, nervous systems, and the self-assembly of a body from seemingly formless matter. Alan Turing, fascinated both by how minds might arise in many substrates and how chemical order arises in embryos, recognized this symmetry between body and mind. The self-organization of cells into a body mirrors the way complex chains of thought and behaviour are represented by neurons: both reveal a larger intelligence built from simpler pieces.

Even before a brain exists, the body itself exhibits a kind of intelligence—cells sensing, signaling, and coordinating to enable functions such as growth and repair. When neurons fire in synchrony to produce a thought, or when tissues knit themselves into an organ, the parts are aligned toward a goal—an outcome at a scale none of the sub-units can comprehend. These patterns—adaptive, regular, meaningful arrangements spread across space and time—are the hallmark of life and mind. And they matter not only as philosophical puzzles but as practical frontiers: they are the key to regenerative medicine and to the ethical future we must share with any potential hybrid or artificial beings that emerge.

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Life and mind are guided by patterns that are not arbitrary regularities in our world, but belong to a structured space of possibilities—a kind of Platonic or latent landscape of forms.

We see patterns in the familiar body plans of animals, in the symmetry of flowers, in the order that recurs at every scale, from molecules to swarming flocks. Time, too, carries its own patterns, in the beating of a heart or the cycles of sleep. Patterns also unfold in less visible realms—in the cascades of gene expression, in the dynamics of physiology, in the coordination of neural circuits. In this sense, patterns are not confined to anatomy or behaviour; they bridge both, as features that enable observers to detect order, generalizing the relationships that underlie specific examples.

These patterns may look objective and obvious, but they always depend on someone—or something—able to notice them. A predator tracking its prey and a scientist mapping an embryo both face a kind of test: can they pick out the regularities that matter? At their core, then, patterns arise in the relationship between living systems that observe one another and build internal models, compressing sensory data into manageable forms. Long before mathematicians formalized the Fibonacci spiral, organisms were already making use of pattern recognition to survive. Over time, humans have created powerful tools for classifying and comparing these regularities, from pioneering biologist D'Arcy Thompson's *On Growth and Form* to modern studies of biomechanics and developmental genetics.

Yet many of the patterns in living systems are not simply mechanical by-products, but function like goals in the sense that the system has a homeostatic ability to reach that state when deviated from it. A body doesn't just unfold like a clockwork machine; it actively strives toward a particular outcome, adjusting when conditions change. This is discovered not through philosophical debates about which systems have goals, but through experiment: by perturbing the system and checking to see how much ingenuity it has to adjust and find its target again. In effect, these patterns serve as navigational setpoints for living matter in a wide range of problem spaces. Cells and tissues behave as if they are exploring a landscape of possibilities—anatomical, physiological, genetic, and metabolic—just as a creature navigates through physical space. The route may change as circumstances require, but the destination remains fixed (which is the definition of intelligence favoured by the influential early American psychologist William James).

This perspective is very different from the standard paradigm of emergence, which emphasizes how simple rules can generate complex forms as the result of a feed-forward process. Emergence certainly plays a role, but those kinds of goal-less models (which already fail to describe systems as simple as thermostats) do not help us study how organisms so reliably achieve specific outcomes when their conditions, or even their own internal parts, are drastically altered.

Consider embryos. Slice one into pieces, and you don't get fragments of a body—you get twins, triplets, or more. Tadpoles with scrambled facial features can reorganize themselves into normal frogs, as though their tissues are finding their way back to the correct face. Fortunately, we have decades of experience of engineering systems that have goals: cybernetics shows that the ability of cell groups to pursue anatomical or physiological goals is not magic, but simply the origin of a capability most often found in brainy organisms.

Life has little certainty. A new being's environment is unpredictable, and its own parts may be the wrong size, shape, or number—and in the long term, guaranteed to mutate. What it can rely on is the deep competence of living matter, refined through evolution into a system that can improvise its way towards the right form (or failing that, an interesting new one). It is as though the formation of the body is guided by a set of unfolding maps—an internal landscape of shape waypoints. No matter how rough the journey, cells do their best to find a way to that destination, correcting errors and switching strategies until the goal is reached. Evolution makes problem-solving agents with different degrees of competency, not fixed solutions.

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How is it possible for tissues to have goals? There are many aspects of this question; one that we are starting to learn the answer to is how cell collectives store specific target states to aim for. These targets are not written into the genes; after all, genes code for proteins—the tiny molecular hardware in each cell—not large-scale shapes.

Planarian flatworms, for example, normally regenerate with flawless reliability: cut them into pieces, and each fragment grows back exactly one head—the default planarian anatomy. Yet, by altering the electrical target pattern stored in the tissues, scientists can push the worms to grow two heads (and they continue making two heads on all future rounds of cutting), or even the heads of other species entirely. Nothing has changed in their genome. What was changed is the bioelectric pattern their tissues carry, which encodes the memory of what counts as a complete body and how to reach that point within the space of anatomical possibilities.

These experiments suggest that anatomical targets behave like setpoints, much like a thermostat maintains a chosen temperature. The body continuously compares its current state against this internal template, adjusting growth until the difference is minimized. The template itself is not a fixed set of genetic instructions but a stored pattern—something like how a memory is stored in the brain. Some species are better at this than others, and we may be able to learn from planaria and axolotls how to remind human tissues of this ancient regenerative trick.

Biologists describe this in terms of anatomical and physiological landscapes: invisible terrains of possibility that cells and tissues move across as they work their way toward specific end states. The parts themselves—molecules, cells, tissues—have no idea what a head or a limb is. But together, they align toward large-scale goals, glued into coherence by networks of signals that enable the whole to have memories and goals that none of their parts have.

The mechanisms of how tissues store and recall these anatomical pattern memories—through bioelectric signaling, genetic circuits, and structural feedback—have been explored in technical detail elsewhere. But the bigger question remains: where do these targets come from in the first place? To understand the origins of these patterns we need a theory of the space of possibilities itself—a view of life as navigating and stabilizing within a structured landscape where certain configurations are attractors, repeatedly rediscovered by evolution and development alike. Then we could systematically explore this space of latent possibilities. But what determines the structure and contents of this space?

Biology and cognitive science typically trace the origins of order back to heredity, environment, or evolutionary history. These are constrained by the regularities of physics that are often grounded in mathematical structure itself. Symmetry, invariance, and topology are the explanatory bedrock for the origins of order in the physical world; they are not treated as consequences of deeper causes.

Yet these may not exhaust the sources of pattern. Mathematical structure itself may constrain and shape the attractor states toward which living systems stabilize. Consider an example. The four-colour theorem tells us that no map, however complex, requires more than four colours to ensure that adjacent regions are always distinct. This is not an outcome of DNA, chemistry, or even physics. It is a fact of mathematics: a pattern that exists independently of any particular physical history. Mathematical facts such as the precise value of mathematical constants like π and e, or the truths of number theory and topology, are all facts that are not physical in themselves but do constrain what happens in the physical world.

Another key feature of such patterns is that one gets more out than one puts in: simple, minimal axioms lead to the discovery of surprising behaviours exhibited by mathematical objects. Evolution only needs to find two angles to make a specific triangle—the third is then known as a necessary consequence of geometry. There is an abundance of examples like this where life exploits and is potentiated by mathematical facts.

This suggests a new way of thinking about biology: embryos and regenerating tissues, as well as synthetic organisms, robots, and AI models, are all pointers, physical systems that tap into the pre-existing mathematical landscape of forms. Just as the constant e, the structure of a fractal, and the computational universality of the logical NAND gate would exist regardless of our universe's initial conditions, so too might the forms that guide biological development.

This view aligns with mathematical Platonism: the view that we discover, rather than invent, a pre-existing order, and it is a crucial area of study for the coming decades. The task, then, is not to marvel at emergence but to map this landscape: to understand the structure of the space of forms, chart how physical systems act as interfaces, and ultimately learn how to design such pointers deliberately.

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Many envision Platonic space as the home of static truths: facts about triangles, integers, and symmetries that never change. They are powerful, but passive. Yet there may be more to this realm, a way that allows non-physical patterns to change via interactions with the physical world (i.e., a bi-directional relationship). What would that look like?

To get a sense of how this could work, consider philosopher Patrick Grim's work on the liar paradox: "this sentence is false." Taken as a static proposition, the paradox is irresolvable. But if we add time, the problem transforms: the sentence cycles between true and false, a dynamic pattern rather than a frozen contradiction. Extend this further with fuzzy logic, where statements can be partly true, and even richer behaviours emerge. When networks of such self-referential statements are plotted together, they reveal intricate, often fractal structures—logical systems that unfold, oscillate, and evolve.

This way of thinking takes the Platonic landscape well beyond timeless, unvarying truths such as $\pi > 3.0$. It could even expand to include interacting patterns or systems that, like certain mathematical models of gene networks, can adapt and learn from experience. Instead of a flat catalogue of eternal forms, Platonic space begins to look like a continuum: from static, mechanical patterns to dynamic, intelligent, and even agential ones that exhibit competencies well known to behavioural scientists.

If such a continuum exists, then some regions of Platonic space may correspond to forms of adaptability and responsiveness—the mathematical analogues of learning and decision-making. At one end lie rigid, unchanging structures; at the other, systems capable of adjusting their state in response to input, forming regularities over time, or exhibiting patterned responses. Dynamical systems—often modeled with coupled differential equations—can reproduce these functional signatures, capturing behaviours like habituation, associative conditioning, or other forms of adaptive response. In this sense, the space may contain patterns not merely of numbers or symmetries, but of activity that resembles cognitive processes. Could it be, then, that some of the inhabitants of this space are not just abstract forms, but proto-minds—structures we would recognize as the mathematical counterparts of learning and perception?

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This raises a provocative speculation: that what we call the mind is not limited to neurons at all, but is rooted in the broader capacity of living matter to access and navigate Platonic patterns. Perhaps the very essence of having an inner perspective—of being a cognitive self embodied in the universe—is linked to the kinds of autopoietic patterns that a given system can express. Perhaps all of us active agents are not physical bodies impinged upon by non-physical forms, but highly agential forms that project through specific interfaces into the physical world, animating those interfaces in ways studied by various sciences ranging from psychology to physics.

The parallels between brains and bodies, and the role of non-physical patterns in both, suggest a bold new hypothesis for the well-trodden problem of how minds relate to physical brains. Rather than trying to reduce mind to physical events we simply note that even simple, non-living systems already feature functional interaction between non-physical drivers and tangible outcomes. Mathematics becomes the behavioural science of relatively simple patterns, while more complex ones are the province of psychology. We propose that the relationship between mind and brain is no more (but also no less) mysterious than that between mathematical patterns and physics.

On this view, intelligence does not originate solely in genes or brains, but in the capacity of organized matter to act as an interface to deeper patterns. What matters is not the material substrate or the historical path by which a system arose, but the kind of coupling it establishes with this underlying space of form. Biological evolution has been extraordinarily successful at discovering such couplings, but it does not exhaust the possibilities. Systems that differ radically in origin and composition may nevertheless converge on similar problem-solving competencies if they instantiate the right organizational constraints.

This perspective reframes familiar disputes about mechanism and mind. Organicists are right to insist that cognition is not the direct execution of explicit instructions. But it is a mistake to think that this insight applies only to evolved organisms. Across both living and non-living systems, there is continuity in degrees of goal-directedness and adaptive behaviour that cuts across distinctions of material, embodiment, and origin story. In this sense, the contrast between “dead matter” and “living mind” is too crude. Organized systems differ not in kind, but in the depth, stability, and scale of the patterns they are able to access and sustain. Any system—biological, synthetic, or hybrid—that succeeds in forming the right kind of organization may open a window onto regions of Platonic space previously unexplored.

The ethical consequence of this view is not triumphalism, but humility. If intelligence is not manufactured from scratch but facilitated—if it arises when matter is arranged so as to couple with deeper structures—then our role is less that of creators than of stewards. Evolution has been casting its nets into this space blindly, through trial and error. Human engineering introduces the possibility of doing so deliberately, and therefore responsibly. The task ahead is not simply to build new systems, but to understand what kinds of patterns they invite, what forms of agency they may support, and how they should be integrated into a shared world.

We are, in this sense, beginning to interact with a broader ecology of minds—not all of which will resemble our own, or arise through familiar routes. The practical questions are urgent, but the ethical questions are deeper. How do we live alongside intelligences whose inner organization we may not fully grasp? What kinds of relationships are appropriate between systems that share a world but not a lineage? Addressing these questions will require more than better engineering or sharper theories. It will require an ethic of synthbiosis: a way of coexisting with diverse forms of intelligence as patterns of mind find new embodiments. ϴ